Energy-efficient Localization Via Personal Mobility Profiling

Ionut Constandache

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Context

Pervasive wireless connectivity

+

Localization technology

=

Location-based applications (LBAs)

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Pervasive wireless connectivity

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Localization technology

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Location-based applications (LBAs)

(iPhone AppStore: 3000 LBAs, Android: 600 LBAs)

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  - One-time location information:

  Geo-tagging, location-based recommendations, etc.

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  - Localization over long periods of time:

    GeoLife: shopping list when near a grocery store

    TrafficSense: real-time traffic conditions

Localization Technology

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10m	GPS
20-40m	WiFi
200-400m	GSM

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Energy Efficiency is important (localization for long time)

Localization Technology

Ideally

Accurate and Energy-Efficient Localization

Energy

Battery Lifetime: GPS ~ 10h WiFi ~ 40h GSM ~ 60h

… sample every 30s

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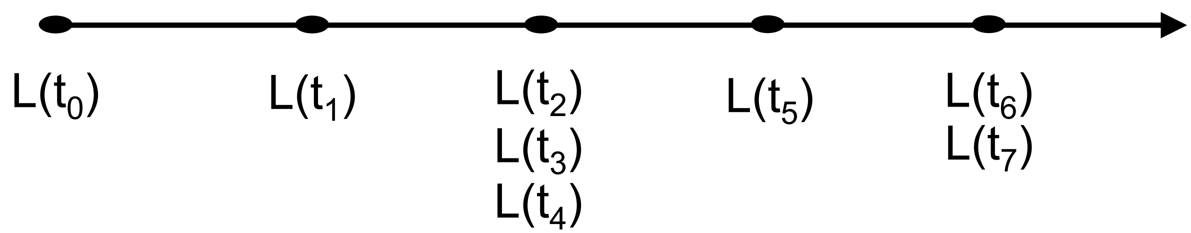
For limited energy budget what accuracy to expect?

Problem Formulation



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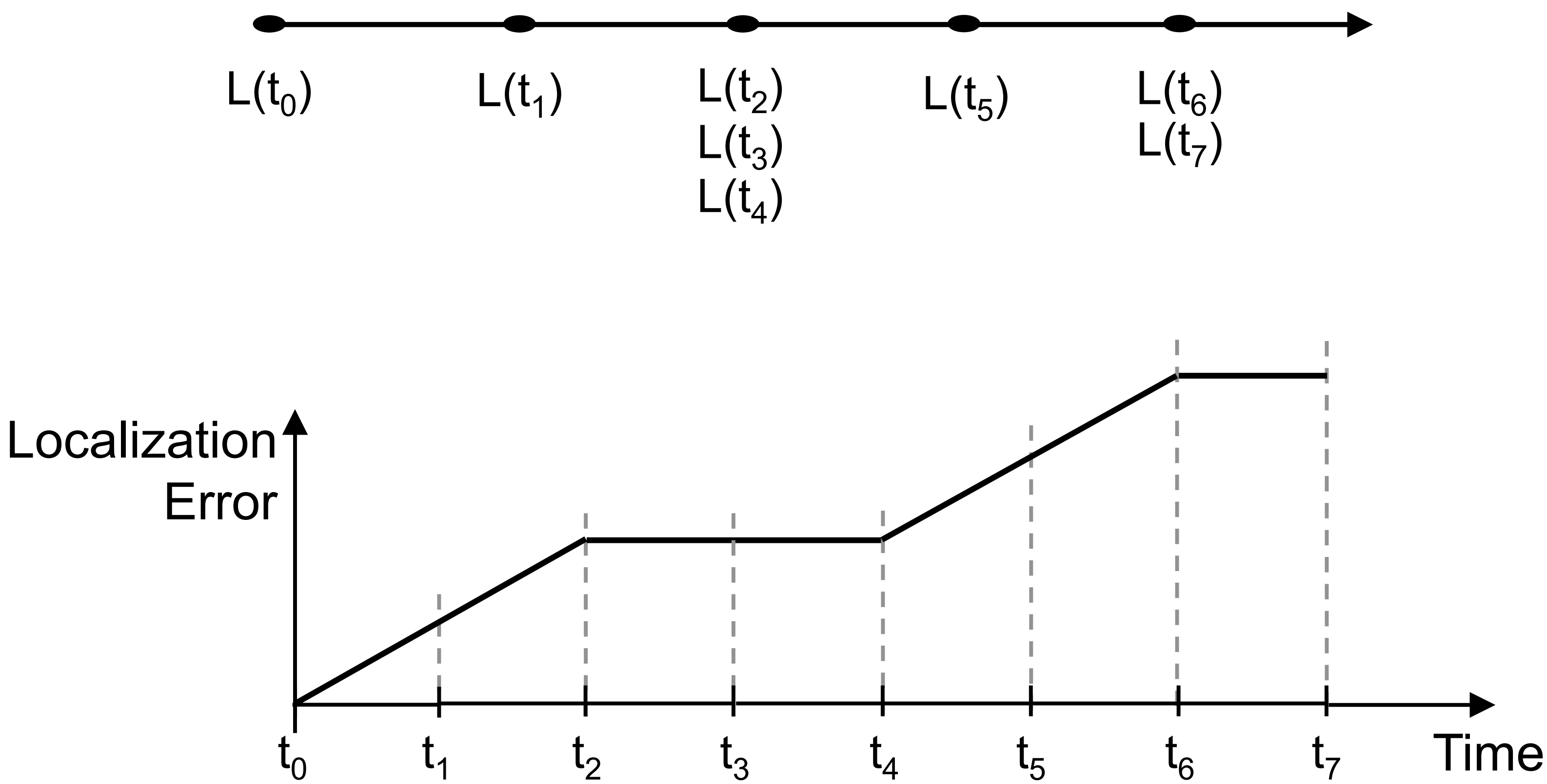

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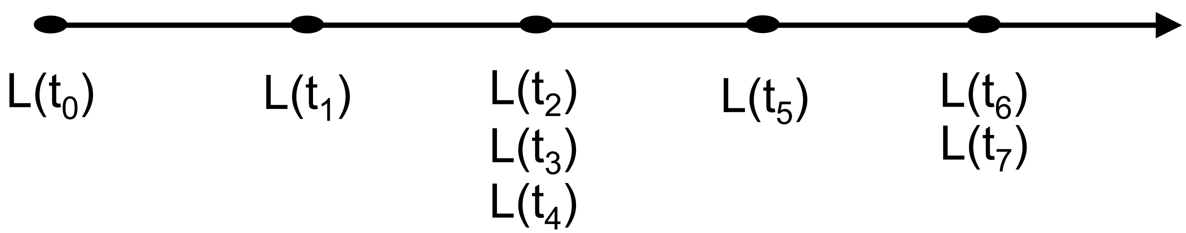

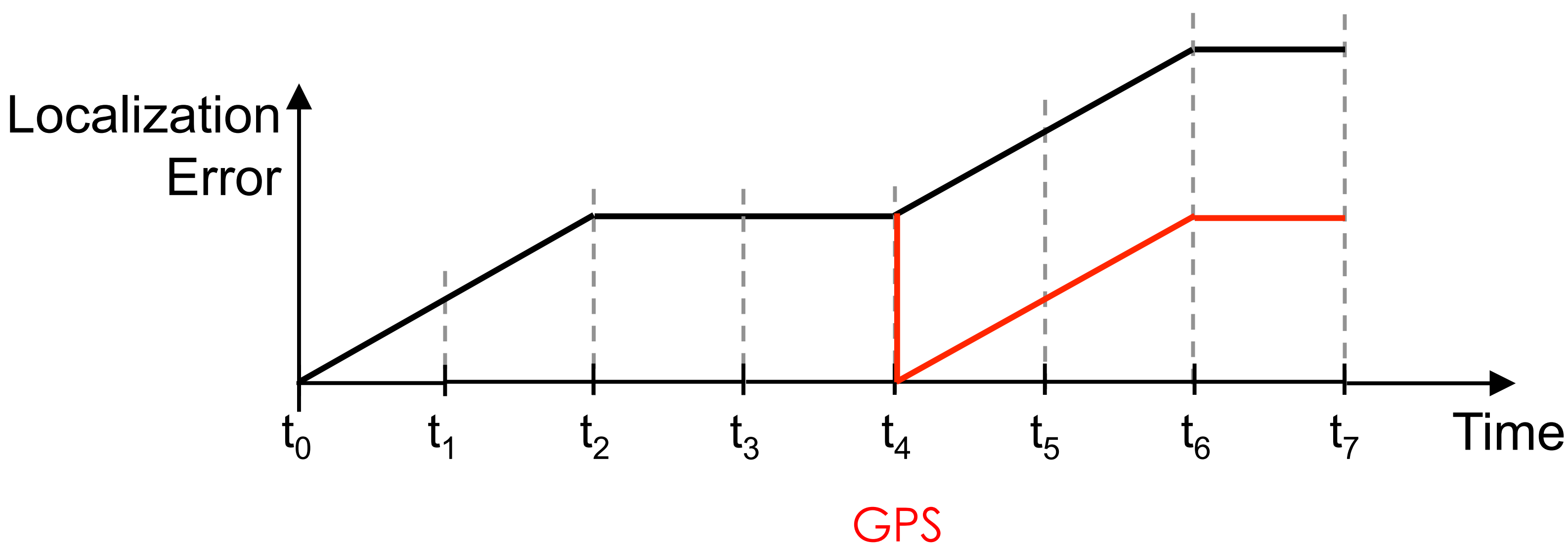

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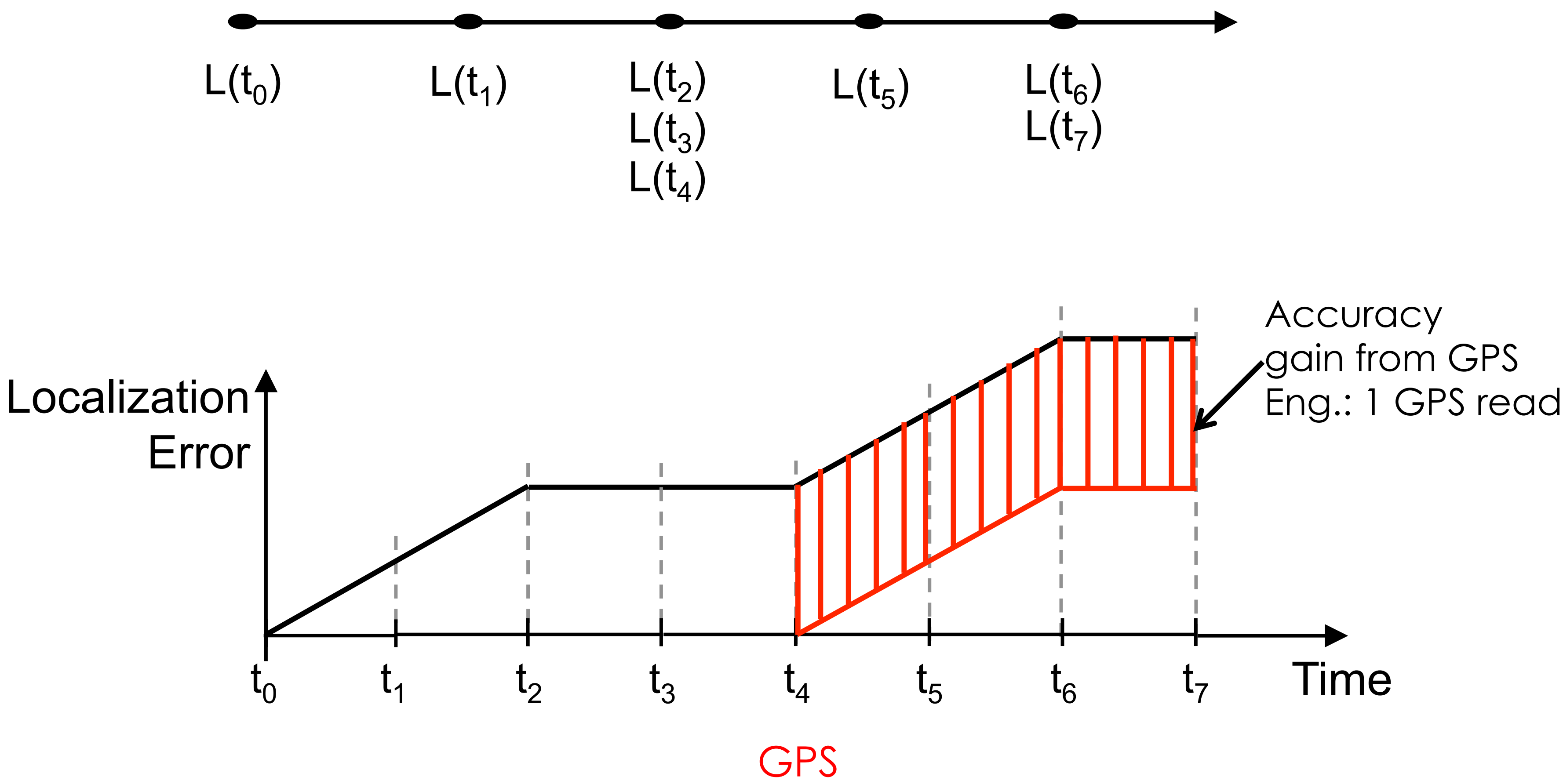

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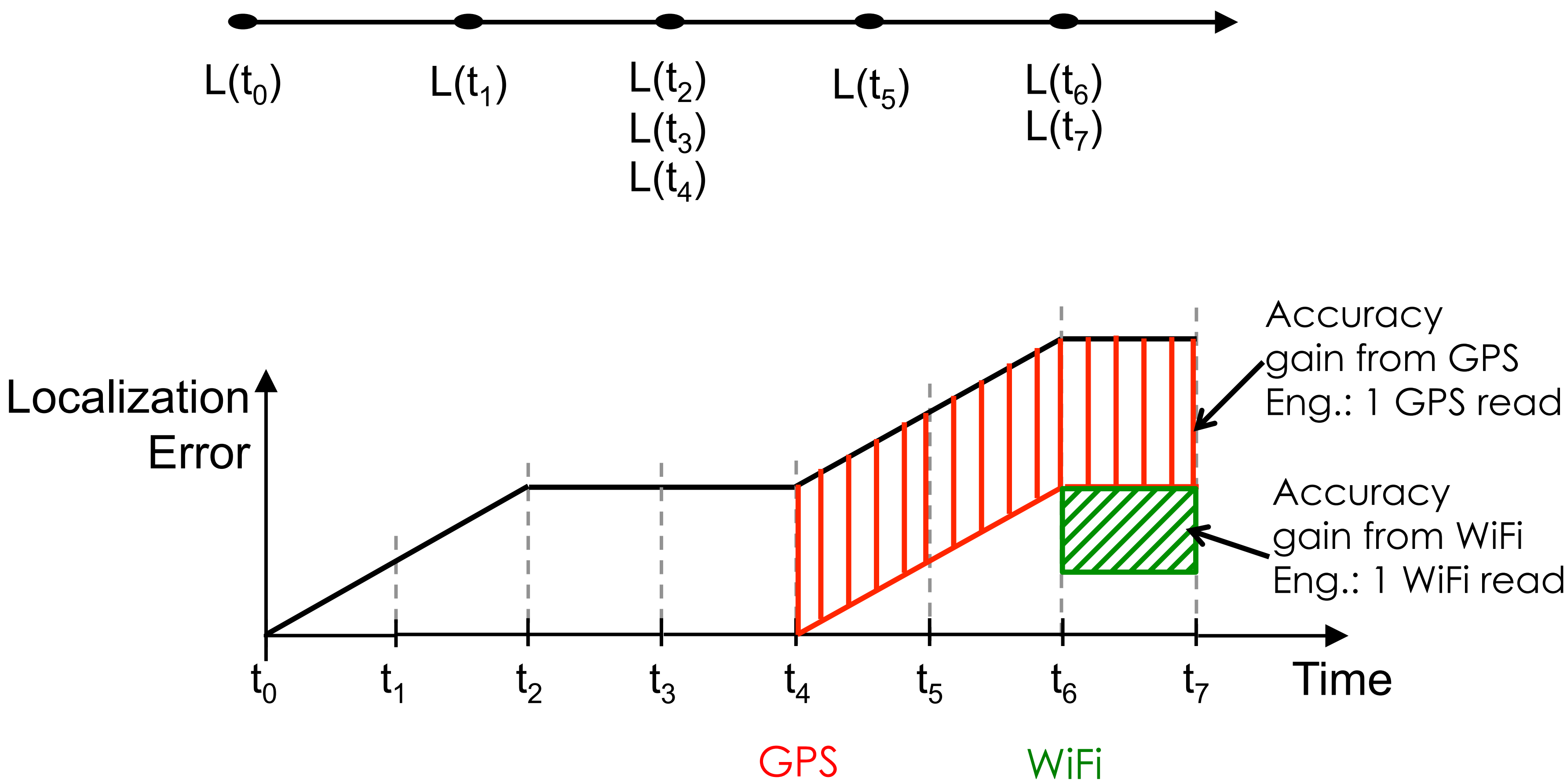

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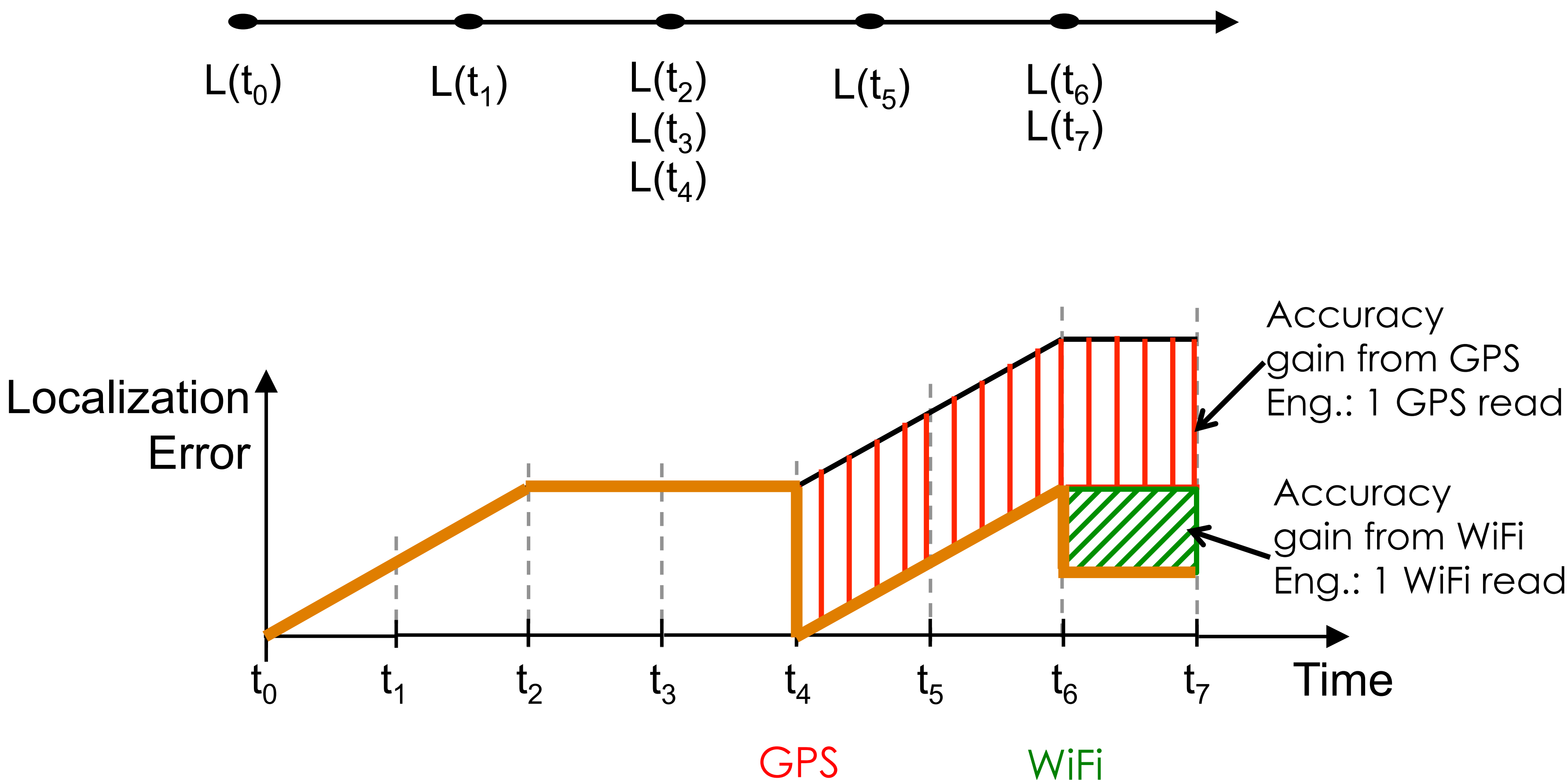

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Find the Offline Optimal Accuracy

Results

	Opt. GPS/WiFi/GSM
Trace 1	78.5m
Trace 2	58.6m
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Online Schemes Naturally Worse

Our Approach: EnLoc

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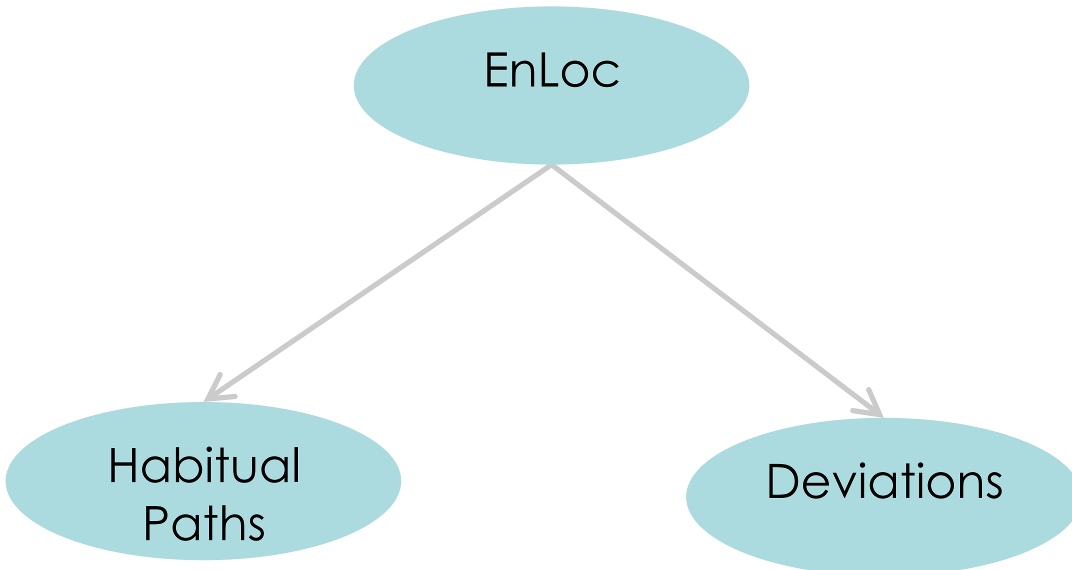
- EnLoc Solution:
  - Predict user location when not sampling
  - Sample when prediction is unreliable

EnLoc: Overview



E.g. Regular path to office

E.g. Going to a vacation

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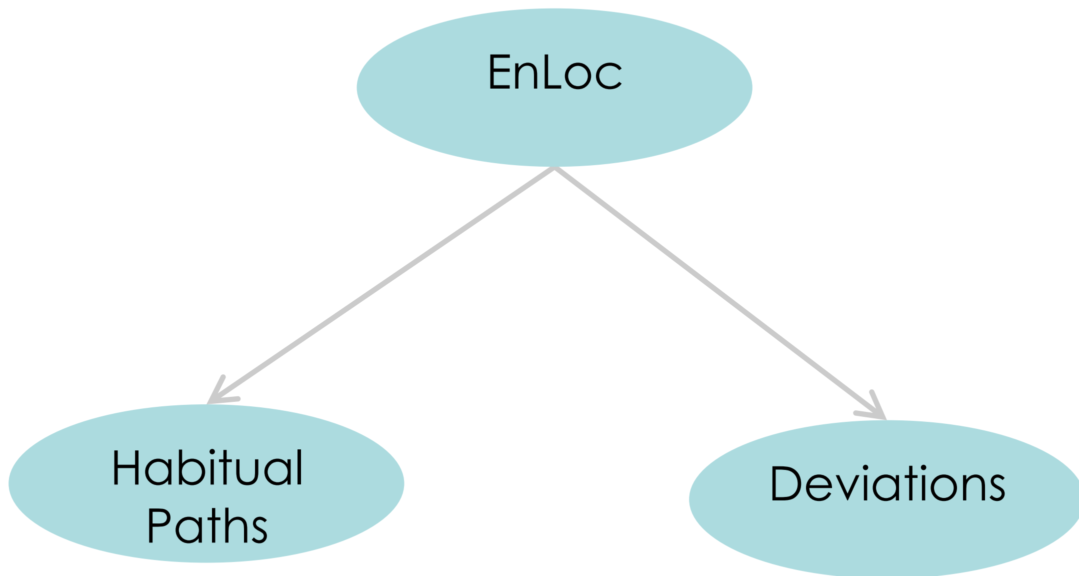

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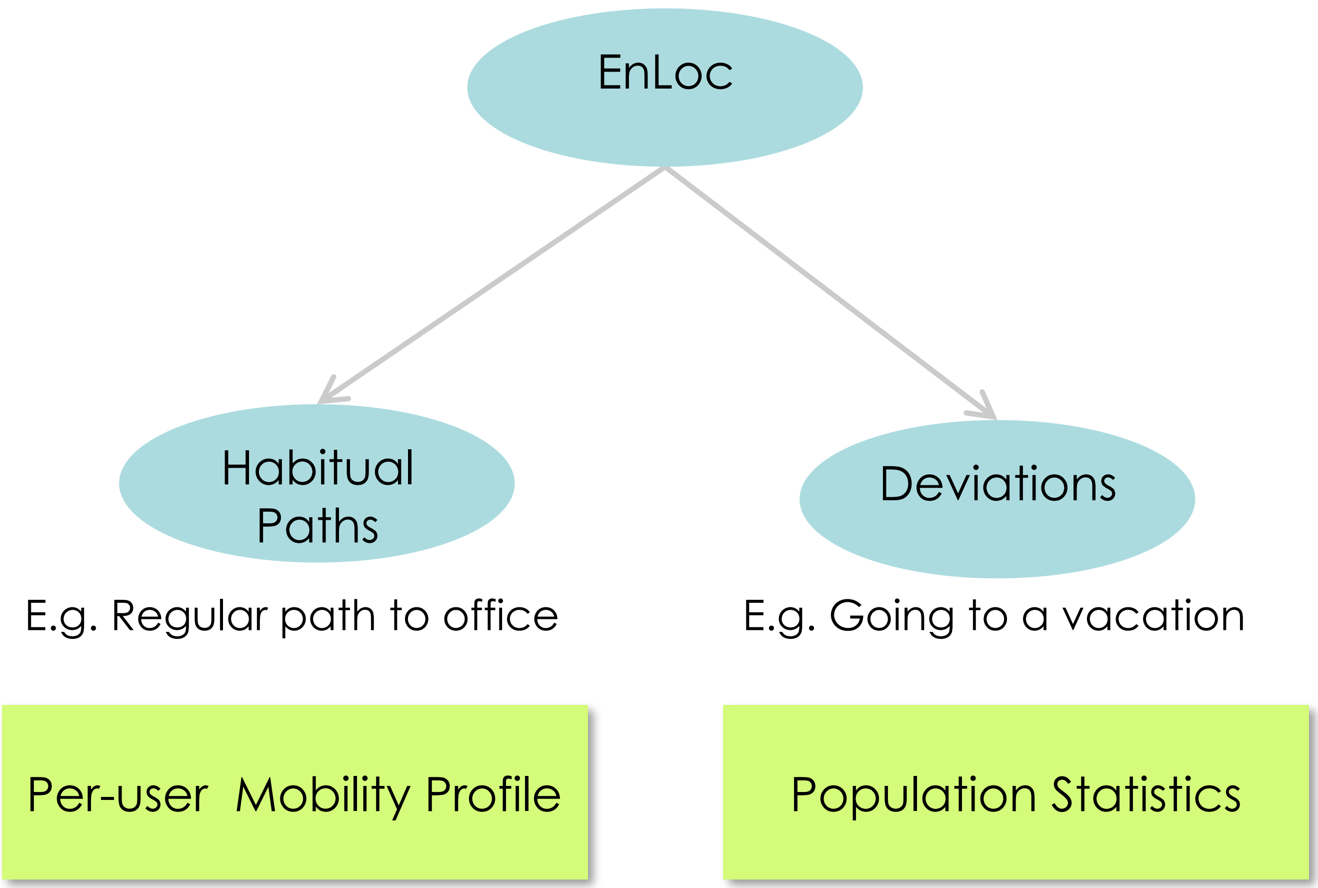
Per-user Mobility Profile

EnLoc: Overview



Profiling Habitual Mobility

- Intuition: Humans have habitual activities
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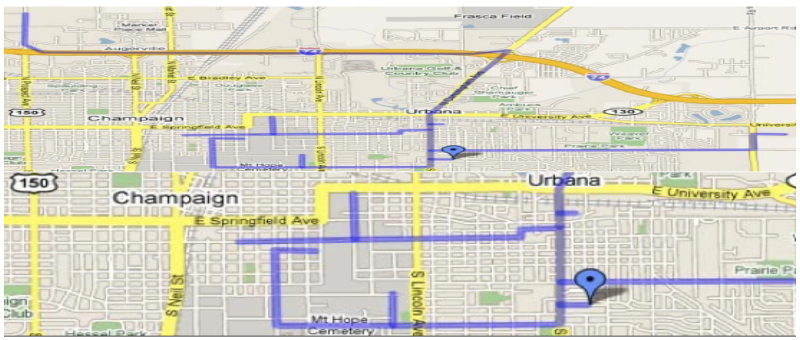
  - Going to/from office
  - Favorite grocery shop, cafeteria
- Habitual activities translate into *habitual paths*
  - E.g. path from home to office
- Habitual paths may branch
  - E.g., left for office, right for grocery
  - Q: How to solve uncertainty?
  - A: Schedule a location reading after the branching point.

Per-User Mobility Graph

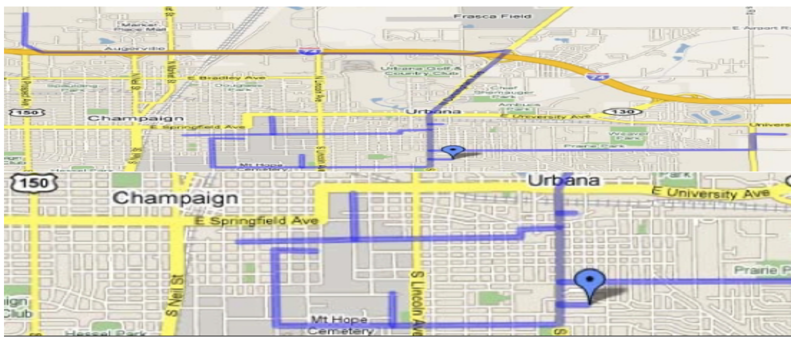
- Graph of habitual visited GPS coordinates



User Habitual Paths

Per-User Mobility Graph

- Graph of habitual visited GPS coordinates



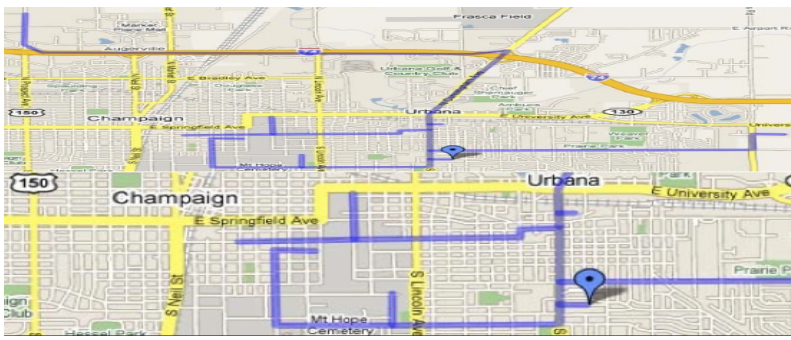
User Habitual Paths

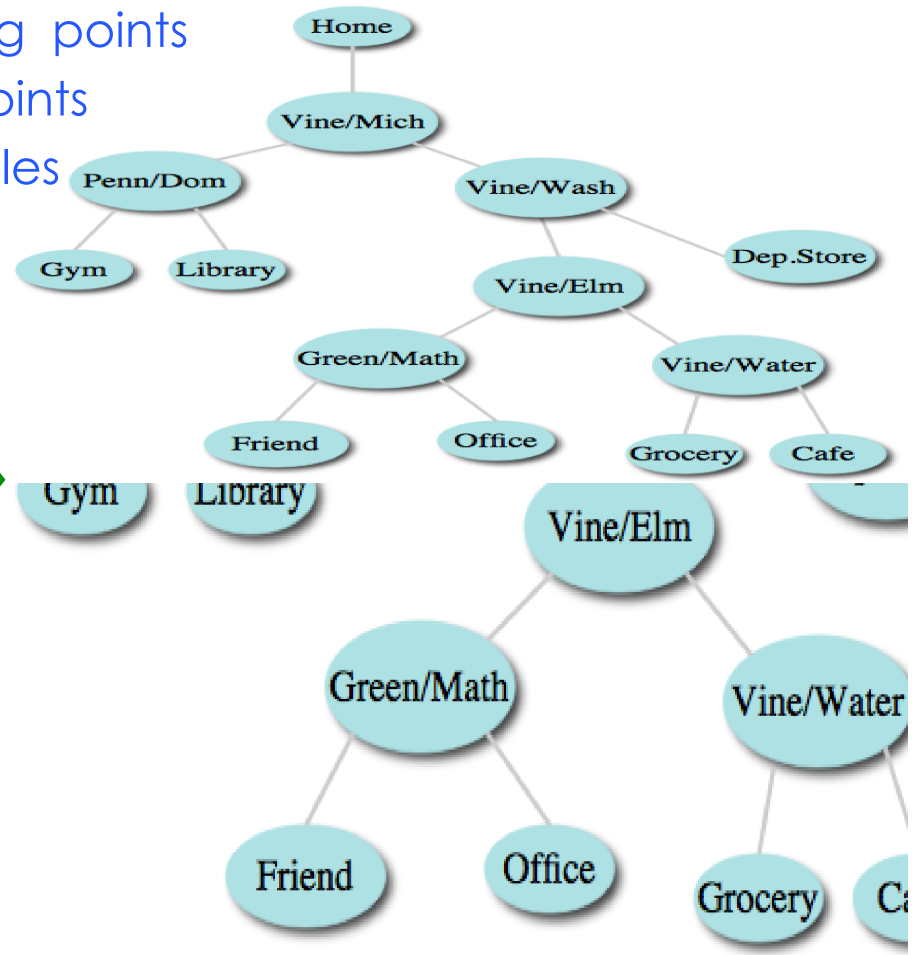
Logical Representation

Per-User Mobility Graph

- Graph of habitual visited GPS coordinates
  - Sample location after branching points
  - Predict between branching points
  - # of BPs < # of location samples

  (BP = branching point)





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Evaluation: Habitual Paths

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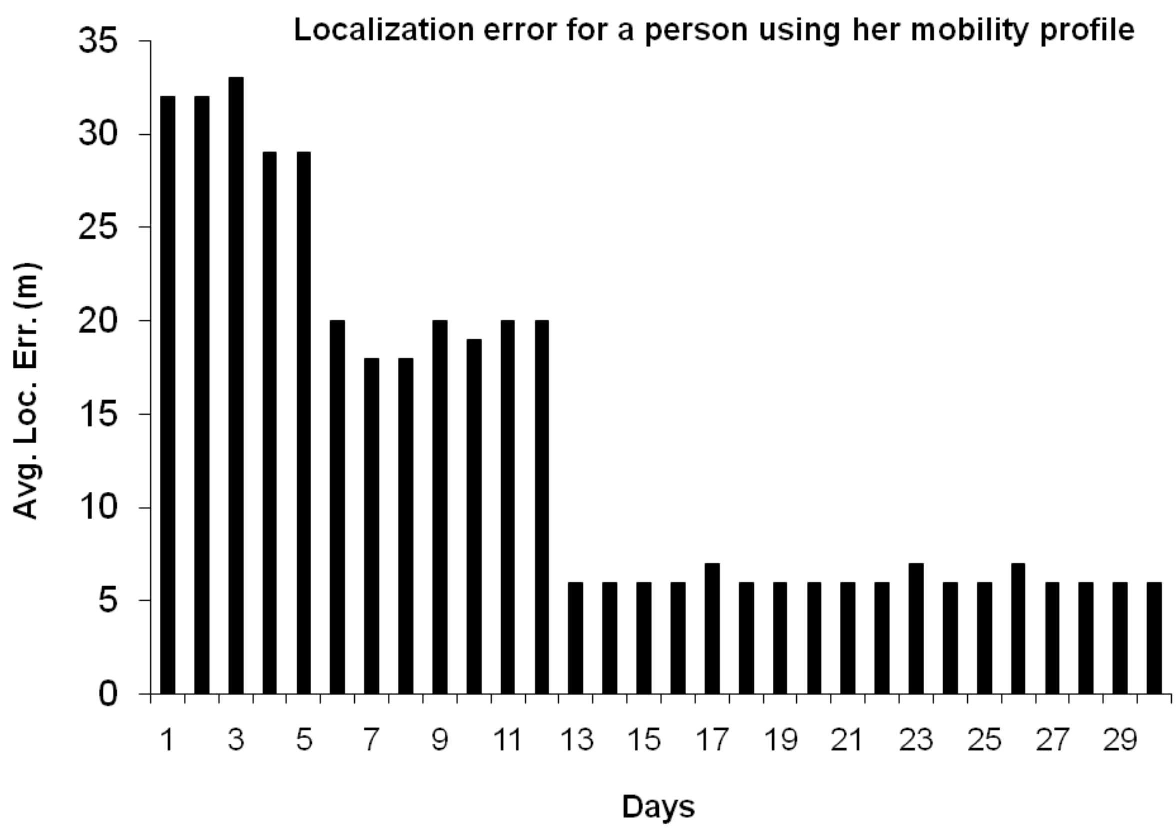

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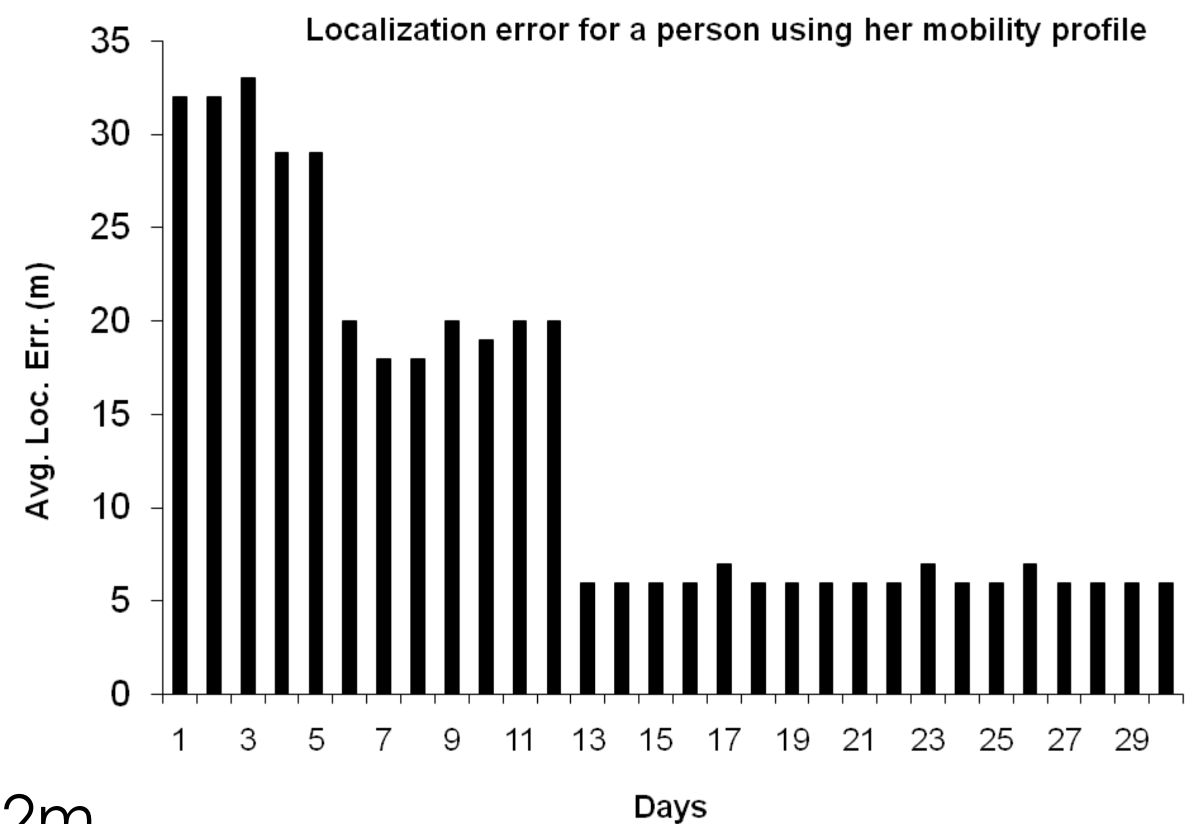

Average ALE 12m

Deviations from habitual paths

- Predict based on *population statistics*
- If user on a certain street, at the next intersection predict the most probable turn.

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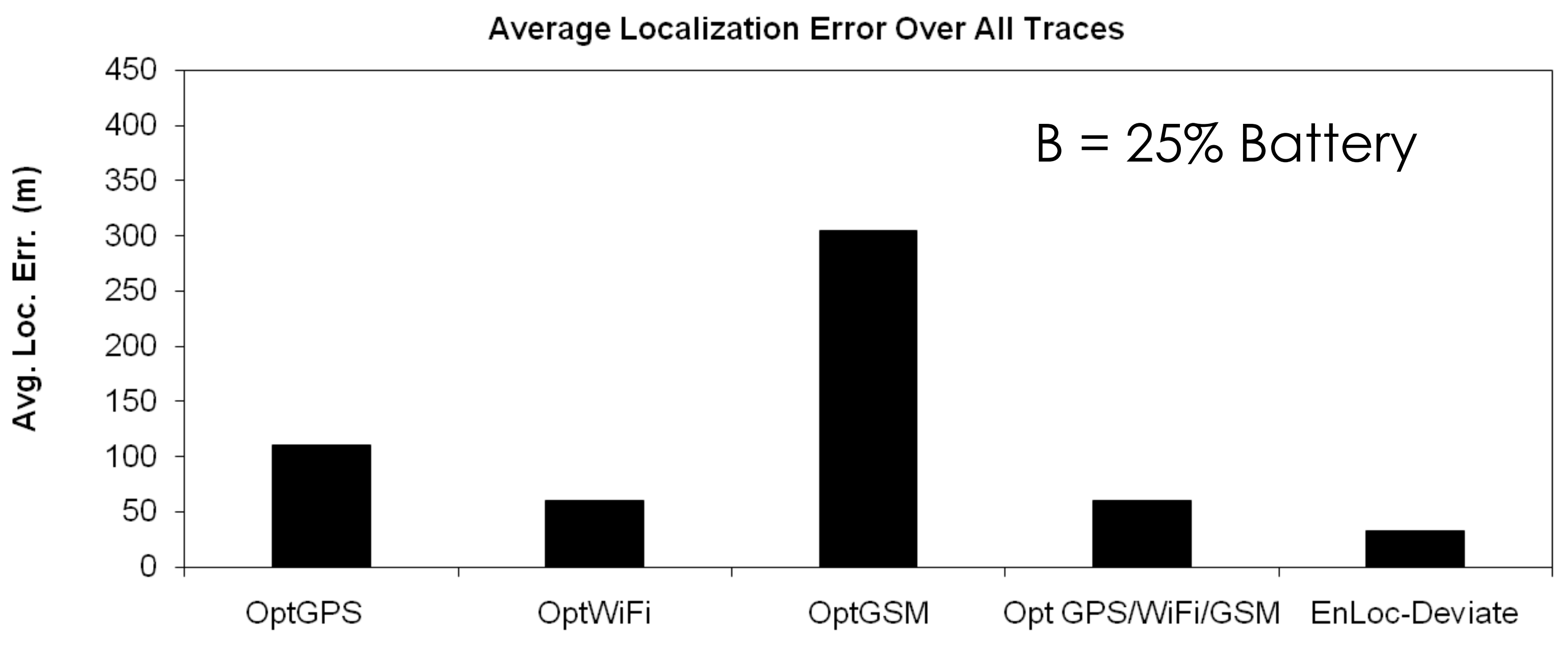
Goodwin & Green	U-Turn	Straight	Right	Left
E on Green	0	0.881	0.039	0.078
W on Green	0	0	0.596	0.403
N on Goodwin	0	0.640	0.359	0
S on Goodwin	0	0.513	0	0.486

Evaluation: Population Statistics



OptX: report last sampled location using sensor X (offline)

EnLoc-Deviate: Equally spaced GPS + population statistics (online). ALE ~ 32m

Future Work/Limitations

- Assumed phone speed known
  - Infer speed using accelerometer
  - Energy consumption of accelerometer relatively small

- Deviations from habitual paths
  - Quickly detect/switch to deviation mode

- Probability Map hard to build on wider scale
  - Statistics from transportation departments

Conclusions

- Location is not for free
  - Phone battery cannot be invested entirely into localization
- Offline optimal accuracy computed
  - For specified energy budget
  - Known mobility trace
- However, online localization technique necessary
- EnLoc exploit prediction to reduce energy
  - Personal Mobility Profiling
  - Population Statistics

Questions?

Thank You!

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